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BIOLOGICAL BULLETIN

THE ORANGE STRIPED ANEMONE (*SAGARTIA LUCIÆ*, VERRILL). AN ECOLOGICAL STUDY.

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The orange striped anemone (*Sagartia luciæ* Verrill) is one of the commonest of the marine invertebrates to be found along the Connecticut coast. It was first observed at New Haven in 1892 by Miss Lucy Verrill, and described in 1898 under the name of *Sagartia luciæ* by Professor Verrill, who believed that it had been introduced into this locality from more southerly waters of North America, possibly on the shells of oysters. From New Haven it has greatly extended its range, and in 1901 was reported as being found as far north as Salem, Mass.

The morphology and anatomy of *Sagartia luciæ*, as well as its general physiology and geographical dispersal, have been ably dealt with in earlier papers. The present contribution embodies the results of a summer's observations made at various points along the Connecticut shore of Long Island Sound, and is chiefly concerned with the ecological relationships of the creature.

Although *Sagartia luciæ* is one of the most numerous of the invertebrates of the littoral fauna of Long Island Sound, it is, nevertheless, an inconspicuous member of the fauna, both because of its diminutive size (being normally about a quarter of an inch, or less, in diameter) and because of the concealing character of its olive green coloration. The bright orange stripes, to the number of about twelve in adults, further aid in rendering the creature inconspicuous by interrupting the contour of the body. The tentacles are usually arranged in four rather ill-defined rows, each row consisting of twelve tentacles. Within each row there is contained one tentacle, larger and longer than the rest, which normally corresponds in location with an orange

stripe. These larger tentacles, also, indicate the position, within the body, of the equally numerous intermesenterial spaces. Within the circle of tentacles lies the greenish oral disc, the center of which is pierced by the mouth opening, surrounded by the lip band. The latter structure is usually reddish in color; is impressed by a number of folds about its inner edge; and bears two prominent, opposite, gonidial grooves.

Since reproduction is often accomplished by longitudinal fission, or less commonly by budding, or by dividing at the base in a sort of budding process which Davenport (1) has termed basal fragmentation, individual anemones vary considerably in form and size, according to the stage of life which each is passing through at the time of the observation. Mature individuals which have not yet apparently begun reproductive activities, are illustrated by Figs. 1 and 2. Extremely unsymmetrical, and even monstrous, forms are frequently encountered, the results of accidental mutilation, for regeneration of lost parts reaches, with *Sagartia*, a high degree of development. Consequently surprisingly small fragments often settle down and regenerate an entire individual. Davenport has pointed out that new tissue, in individuals which are the results of reproduction by division, is of a hue of green less olive in tone than that of older individuals, and that the new stripes are a brighter yellow, with less orange tint. This is also true of new tissue which is being regenerated to make up for some lost portion of the body.

The general color scheme of *Sagartia* seems to be particularly well adapted to the concealment of the creature. The olive green of the body, broken by the longitudinal orange stripes, and the grayish white of the tentacles, forms a color aggregation of unusually subdued character when the animal is viewed in its normal habitat. When fully expanded, and hence in its most conspicuous attitude (Fig. 1), the body becomes lighter in color (because the more translucent) and the body assumes a translucency, as do also the tentacles. The latter, indeed, become, often, virtually colorless, and almost transparent. The color of the orange stripes likewise undergoes a diminution in intensity as the expansion of the animal progresses. Under these conditions, when viewed either from above or below (the latter by

means of a mirror placed at the bottom of the pool), the body outline becomes almost impossible to trace. Another aid to concealment is afforded by the immobility of the tentacles when the animal is fully expanded, and also by the extreme deliberation with which the act of expansion takes place. When contracted (Fig. 2) the animal appears like a small dark greenish button-like protuberance, whose outline, however, is interrupted by the orange stripes. This combination of dark olive green and orange (which seems at first a rather gaudy *ensemble*) can be shown to be a peculiarly effectual one for the type of rock on which *Sagartia* is usually found seated, *i.e.*, the granites of the New England coast. The rock is flecked with black, and with varying tints and shades of gray, green, reddish, and yellow, from the included quartz, feldspars, hornblende, etc., and from the various chemical combinations with these minerals which the oxygen of the air and the substances of the sea water make.

Sagartia luciae occurs below tide level on piles, or other submerged objects, and is frequently associated with the rock barnacle (*Balanus balanoides*), and with two species of mussels; the ribbed mussel (*Modiola plicatula*), and the black or edible mussel (*Mytilus edulis*). In the same company may also be found small clusters of the common oyster (*Ostrea virginica*). More often, however, the habitat of *Sagartia* are the tidal pools between the tide lines, among rocky headlands and shores, and rocky tidal islands, in which the New England coast abounds. Wherever it occurs, however, it will usually be found attached to vertical, or overhanging surfaces, rather than to horizontal ones (Fig. 3). In some few tidal pools it was found, however, on the gently sloping sides. Comparatively few enemies, either organic or inorganic, attack those individuals which are attached to the vertical or overhanging sides of the pool, while those that become detached and cast to the bottom are soon either buried by debris brought in by wave or tidal currents, or fall an easy prey to mud crabs (*Panopeus*), rock crabs (*Cancer irroratus*), or hermit crabs (*Eupagurus longicarpus*), for *Sagartia*, despite its armament of nettling acontia, is without means of defense against these heavily armored scavengers.

As a rule, the rock itself seems to be the favorite location of

Sagartia, for the creature can detach itself, at will, from its seat, and move by means of its tentacles, or float about, head downward, from the surface film of the water until a more favorable locality is found. The fact that the rock, or other seat of equal solidarity, is chosen more often than any other for the obsession of *Sagartia* would seem to indicate that the creature possesses a sense which instructs it regarding the relative stability of submerged objects. However it is often found attached to the shells of living mussels and even sometimes upon eel grass, fucus, or other algæ. It often occurs, also, attached to shells, and other objects that have become firmly wedged into crevices in the rock by the action of the waves.

Sagartia is ordinarily solitary in its habit, and not communal, and yet, what seem to be in effect, colonies, at least in so far as mere physical propinquity is concerned, were met with in tidal pools, where, apparently by repeated divisions, coupled with but little migration on the part of the increasingly numerous progeny, groups of from ten to twenty-five individuals, with their bases almost in contact, were formed. That this group formation aided in securing food was seen when large beach fleas (*Orchestia agilis*), which were easily able to escape the embrace of a single anemone, were at once, caught and held by the numerous tentacles brought to bear in the capture by several contiguous individuals at once, and easily nettled into a state of helplessness. Possibly such a colonial existence (if it may be so called) makes also for the more effectual protection of the individual members of such a community. Such groupings seemed to be the exceptions, and not the rule, in the disposition of the anemones in the tidal pools. It is interesting to conjecture, that possibly this grouping, perchance accidental at first, marks the beginning of the development of a movement toward communal living on the part of *Sagartia*. If this manner of living does make for the better protection of the members of colony, and aids in securing more frequent and larger captures of food, then we may suppose that the collective individual will thrive at the expense of the independent one, a law of progress derivable from other fields also than the biologic one.

The food of *Sagartia* consists mainly of small crustacea,

annelids, etc., which are seized by the tentacles, rendered innocuous by the acontia and then gradually manipulated into the mouth. Fig. 4 represents an individual capturing a beach flea, which had been steered into the blossom of tentacles with a broom splinter. All sorts of sufficiently soft food substances, either living or dead, are taken indiscriminatingly. Numerous individuals were fed by the writer, both in their natural habitats, undisturbed, and in aquaria, with pieces of fish, both fresh and decaying; clam, mussel, beef, bread, salt pork, insects, etc., which the anemones seized and devoured with the same impartial gusto which they showed for living creatures. They however rejected hard substances, such as sand grains, bits of shell, wood, etc. Beef juice, dexterously squirted upon one portion of the blossom of tentacles with a finely drawn out pipette, caused them to respond at once by throwing over a large number of tentacles to that side whence the stimulus had come and endeavoring to entrap some object. Frequently the tip of the pipette would be grasped, only to be relinquished again. Foreign substances, *i.e.*, those not usable as food, were pushed to one side of the blossom of tentacles and allowed to fall off. The food which seems to form the bulk of their intake consists of the smaller crustaces, such as small beach fleas (*Orchestia agilis*), small clam worms (*Nereis*), and other small marine worms, very small crabs in the soft shelled stage just after a molt, chiefly the mud crab (*Panopeus*), crushed rock barnacles (*Balanus balanoides*), very small fish fry, and heterogeneous particles of animal tissue which the tidal and wave currents chance to float by. A lessening of the food supply in some particular neighborhood apparently is the moving cause that sets many individuals roving by hanging head downwards from the surface film of the water and being borne here and there by currents until a more fruitful locality is discovered. Rarely there was found a more ambitious individual which had fastened upon the shell of a periwinkle (*Littorina littoria*), and was continually being carried into pastures new.

The enemies of *Sagartia* are numerous. Among them the most important are: various species of rock bottom feeding fishes, rock and mud crabs, starfishes (*Asterias*, and others), and the

larger clam worms. Many individuals are doubtless swept away by the assaults of sand and debris-laden waves in times of storm, and by the grating of ice cakes against the rocks during the winter. Frequently a tidal pool is drained by an excessively low ebb tide, and the anemones left exposed for an hour or so to the rays of a direct sun. This, coupled with a vigorous dry wind will often accomplish the destruction of some individuals, though they were able to withstand even such adverse conditions to a surprising degree, as experiments showed.

It seems remarkable that so soft and relatively defenseless a creature should have so greatly increased its numbers and extended its range in our waters. Its success in meeting the unusually numerous vicissitudes of a littoral existence may perhaps be attributed to the following: (1) in ability to withstand considerable differences in temperature, (2) its ability to withstand buffeting by the waves because of the yielding and resilient character of its body, (3) its ability to contract tightly, and to survive through a period of foul water, or of dry conditions exposed to the sun and wind, (4) its apparent disregard of differences in the salinity of the water, (5) its protective coloration, (6) its defensive acontia, (7) its rapid rate of reproduction and growth to maturity, (8) its several methods of reproduction, (9) its ability to withstand annihilation through laceration, and (10) its ability to regenerate lost parts.

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EXPLANATION OF PLATE I.

FIG. 1. A fully expanded, mature *Sagartia* with its tentacles in exploring posture, after having been stimulated with beef juice injected into the water. The object to which it is attached is an edible or black mussel (*Mytilus edulis*).

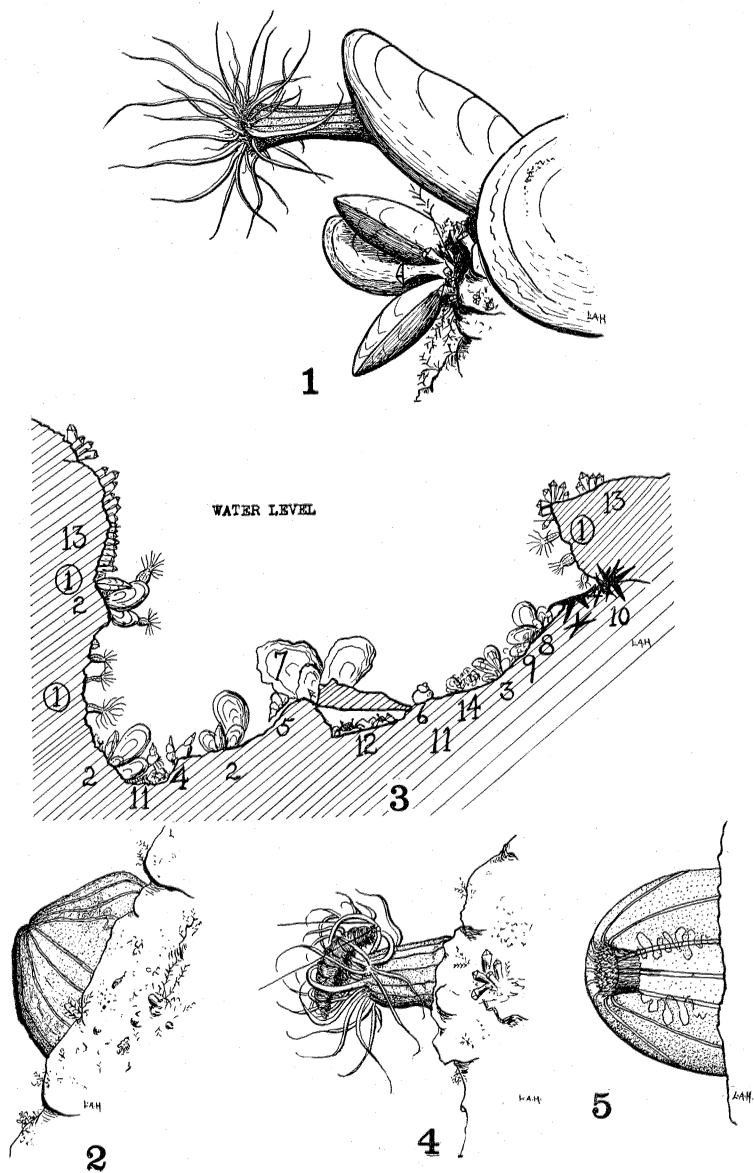
FIG. 2. Contracted mature *Sagartia*.

FIG. 3. Transection through a typical ideal tidal pool, to show the disposition of *Sagartia* individuals, and their general ecological relationships.

1. *Sagartia luciae*.
2. Edible or Black Mussel (*Mytilus edulis*).
3. Ribbed Mussel (*Modiola plicatula*).
4. Mud Flat or Elephant Snail (*Nassa obsoleta*).
5. Oyster Drill (*Urosalpinx cinerea*).
6. Periwinkle (*Littorina littoria*), not numbered in the figure. It occurs in great numbers, everywhere.
7. Oyster (*Ostrea virginica*) rare in tidal pools.
8. Clam Worms (*Nereis*), in mud among masses of mussels.
9. Small Ribbon Worms (*Mechelia*).
10. Starfish (*Asterias forbesi* and *vulgaris*).
11. Hermit Crabs (*Eupagurus longicarpus*).
12. Mud Crabs (*Panopeus herbstii* and others).
13. Rock Barnacle (*Balanus balanoides*).
14. Green Beach Flea (*Orchestia agilis*).

FIG. 4. *Sagartia*, capturing a small Beach Flea (*Orchestia agilis*).

FIG. 5. Partially contracted *Sargtia*, of large size, just before fission. A strong light had been placed behind the creature, revealing the manner of the accommodation of the contracted tentacle blossom, and the folded sides of the gastrovascular cavity. The latter is seen to be empty of food.



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